LANSCE
Los Alamos Neutron Science Center

Research Proposal for the use of Neutron Science Facilities

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Program Advisory Subcommittee: Defense-related Nuclear Science
Focus Area:

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Estimated Beam Time (days): 30
Days Recommended: 0
Dates Desired:
Impossible Dates:

TITLE
Neutron Capture Measurements on U235 at DANCE

☐ Continuation of Proposal #:
☐ Ph.D Thesis for:

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RESEARCH AREA		FUNDING AGENCY
☐ Biological and Life Science	☐ Mat'l Science (incl Cond Matter)	☐ DOE/BES
☐ Chemistry	☐ Medical Applications	☐ DOE/OBER
☐ National Security	☐ Nuclear Physics	☒ DOE/NNSA
☐ Earth Sciences	☐ Polymers	☐ DOE/NE
☐ Engineering	☐ Physics (Excl Condensed Matter)	☐ DOE/SC
☐ Environmental Sciences	☐ Instrument Development	☐ DOE/Other
☒ Nuc. Physics/chemistry	☐ Neutron Physics	
☐ Astrophysics	☒ Fission	☐ DOD
☐ Few Body Physics	☒ Reactions	☐ NSF
☐ Fund. Physics	☐ Spectroscopy	☐ Industry
☐ Elec. Device Testing	☐ Nuc. Accel. Reactor Eng.	☐ NASA
☐ Dosimetry/Med/Bio	☒ Def. Science/Weapons Physics	☐ NIH
☐ Earth/Space Sciences	☐ Radiography	☐ Foreign:
☐ Materials Properties/Test	☐ Threat Reduction/Homeland Sec.	
☐ Other:	☐ Other:	☐ Other US Gov't:
		☐ Other:

PUBLICATIONS

Publications:

None

Abstract: S1561_DANCE235U.doc

By electronic submission, the Principal Investigator certifies that this information is correct to the best of their knowledge.

Safety and Feasibility Review *(to be completed by LANSCE Instrument Scientist/Responsible)*

☐ **No further safety review required** ☐ **To be reviewed by Experiment Safety Committee**

☐ **Approved by Experiment Safety Committee, Date:**

Recommended # of days:	**Change PAC Subcommittee and/or Focus Area to:**	**Change Instrument to:**

Comments for PAC to consider:

Instrument scientist signature: **Date:**

Neutron Capture Measurements on ^{235}U at DANCE

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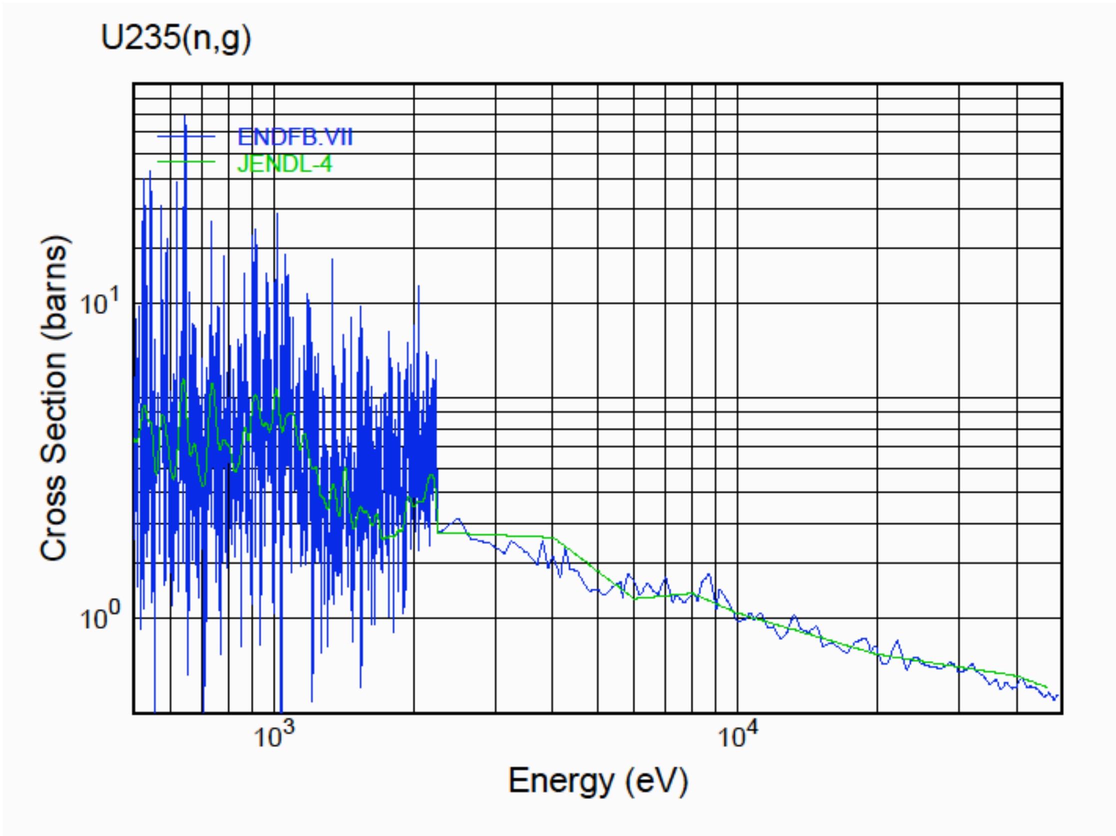
Introduction

We propose to make improved measurements of the ^{235}U neutron capture cross section and capture-to-fission ratio at DANCE. This measurement will utilize a redesigned parallel-plate avalanche counter to tag the fission events. Similar measurements attempted at DANCE in previous run cycles met with varying degrees of success because problems related to target fabrication, and difficulties in operating the fission-tagging detector have limited the amount of fission-tagged data. We believe that careful target fabrication coupled with a better understanding of the tagging detector will enable a successful measurement. We request 30 days of beam time to make these measurements.

Background

^{235}U is one of the two fissile nuclides that finds extensive use in power reactors and the nuclear stockpile. The capture cross section is important for calculations of burn-up in reactors, and in understanding actinide inventories for nuclear forensics and the nuclear stockpile. Measurement of neutron capture on fissile nuclides is complicated by the fact that capture is usually identified by measuring gamma rays, which are also produced in fission. Fission tagging of some sort is therefore needed. Many measurements of capture (or equivalently, the capture to fission ration "α") on ^{235}U have been made , but there are still uncertainties in the cross section, especially for neutrons in the kilovolt range. This is illustrated by the significant differences in the ENDFB-VII and JENDL-4.0 evaluated cross sections near 1 keV, shown in the figure below. Theoretically, Lynn[1] calculated that the capture cross section should be 30 to 40% higher in this range, while Chadwick [2] suggests, based on critical assembly data, that it may be lower. There have been many measurements made, but most results have been presented in conference proceedings or limited-circulation reports. The data values are tabulated in the EXFOR library, but many of the details of the experiments are more difficult to obtain. An early result was published by Hopkins and Diven [3], who used a 9.5 g/cm^2 by 0.75 in diameter metallic ^{235}U target (93% enriched.) Gamma's were detected in a 1 m diameter by 1 meter long liquid scintillator, and fissions were tagged by detecting thermalized fission neutrons within 32 μsec of the gamma signal. In a later experiment by Gwin, et al [4], a fission chamber was used to tag the fissions. The chamber contained 19 foils, each 7.62 cm in diameter and coated with a 1.7 mg/cm^2 deposit of ^{235}U. The gamma rays were detected in a 3000 liter tank of liquid scintillator surrounding the fission chamber.

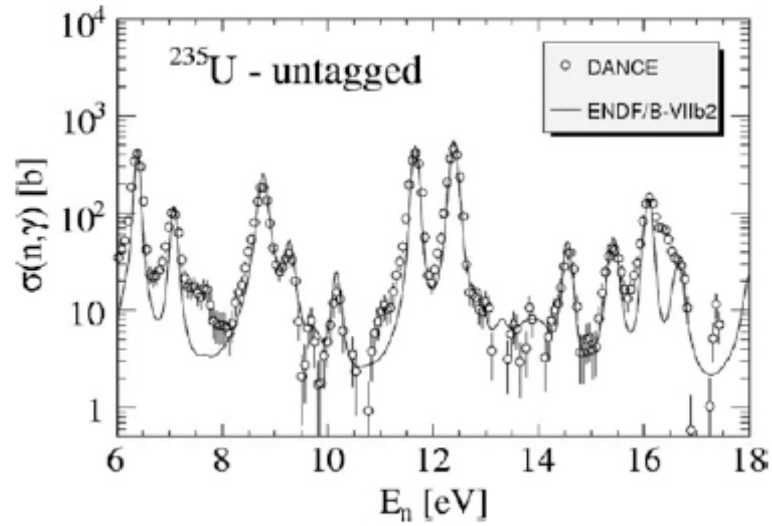


Comparison of evaluated cross sections from the ENDF/B-VII (blue)
and JENDL-4.0 (green) evaluations

Proposed Experiment

For this experiment at DANCE, we will use a parallel-plate avalanche counter (PPAC) for fission tagging. These are gas counters that operate at low pressures (approx 10 Torr) and contain a single double-sided foil with deposits up to 1 mg mass deposited in a 0.7 cm dia circle. The high efficiency of the DANCE array coupled with the restored neutron beam flux at FP14 allows measurements on this small of a sample. Preliminary data were taken in 2006 with an early version of the PPAC, and good results were obtained in the resonance region. An example of the capture data that were obtained [5] is shown below. However, subsequent attempts to obtain more data and good statistics in the keV region were stymied by difficulties in additional target fabrication and failures of the PPAC to function properly, resulting in very low efficiency (20%) when working at all.

For this proposal, we will use a PPAC based on an improved design by LANL, LLNL, and MSI Corp, and fabricated at Livermore [6]. This PPAC design was used successfully in 2010 for measurements on ^{239,241}Pu and ^{252}Cf, and proved to be very robust mechanically and have 70% efficiency for detecting at least one of the fission fragments. We propose using two different double-sided ^{235}U targets, one with a total mass of about 0.5 mg in a 0.7 cm dia deposit (1.3 mg/cm^2), and one about 1.0 mg (2.6 mg/cm^2). The ^{235}U samples will be fabricated either at LLNL or LANL, and will be characterized using mass spectrometry on the remains of the electroplating solution, in addition to alpha and gamma counting of the target. XRF and/or RBS may also be used to fully characterize the sample. The PPAC has a finite efficiency for detecting decay alpha particles, but these can be eliminated in the analysis by pulse-height gates on the PPAC signal and multiplicity gates in DANCE. Characterization of the γ-ray distribution in terms of multiplicity and summed energy will make it possible to clean up the capture signal by subtracting the 30% untagged fission events

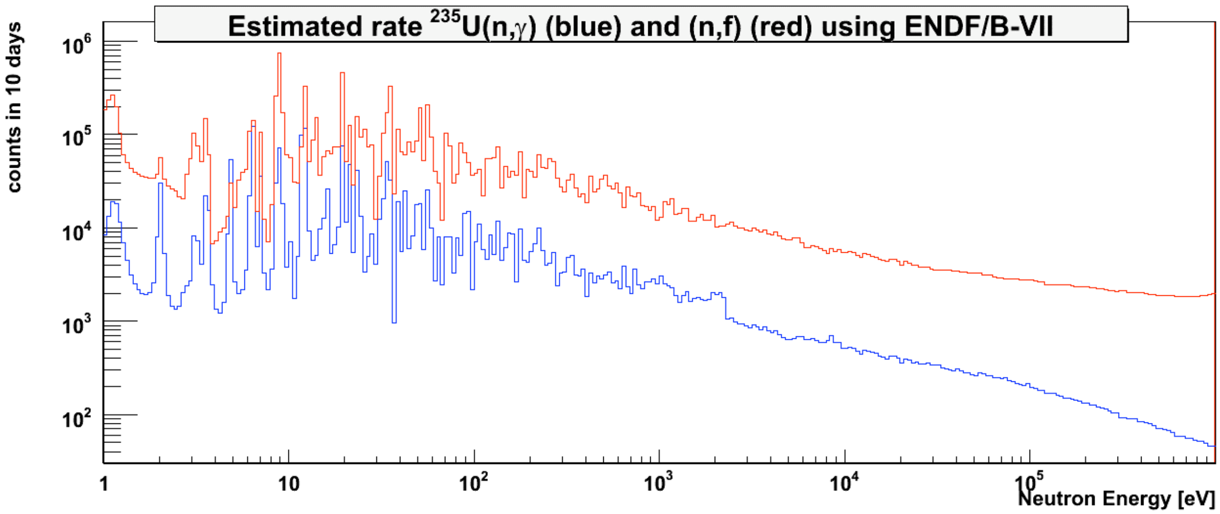


Preliminary ^{235}U(n,γ) cross sections obtained at DANCE in 2006, compared to cross sections from the ENDF/B-VII evaluation. Error bars are statistical only. (From Ref 5.)

We will pay careful attention to the experimental backgrounds that contribute to the capture measurement. Although the exact details are still being discussed, this may include a fully-functioning "blank" PPAC's.

In addition to the cross section measurements, we will also measure the "prompt" gamma-ray emission spectra and multiplicity from fission-tagged events. These spectra are of interest for reactor and homeland defense applications, and will complement earlier data taken with single small crystal detectors [7].

The figure below shows a 10-day count estimate for a 1 mg ^{235}U target (approx. 2.6 mg/cm^2), based on ENDF/B-VII cross sections and calculated using the neutron beam flux measured in 2010, by assuming 75% efficiency for fission counting and 20% for capture. The 20% capture efficiency reflects the application of gates used to increase the signal to noise. The figure is binned with 50 bins/decade (dE/E = 4.7%) in neutron energy. This binning factor is applied in the replay and analysis, and can be adjusted as needed. Under these no-background assumptions, about 3000 counts can be obtained for capture near 1 keV in a 10 day period. Experimental backgrounds are non-negligible and must be taken into account; the analysis of backgrounds observed in 2010 is on-going. Based on these estimates and previous experience, we estimate that we will require 10 days of beam with the thicker target, 5 days with the thinner target (which will emphasize the lower energies where neutron flux and cross sections are higher, and backgrounds lower), 10 days for "target-empty" background runs, and 5 days for Pb and Au runs. The Pb will provide a measure of the shape of the neutron-scattering background, and the Au will serve to normalize the neutron beam flux. The total beam-time request is 30 days.



Estimated 10-day counts for a 1 mg ^{235}U sample, using ENDF/B-VII cross sections and the beam flux measured in 2010. The data is binned with 50 bins/decade (dE/E=4.7%).

References.

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